Impact of pretreatment hydronephrosis on the success rate of shock wave lithotripsy in patients with ureteral calculi

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ABSTRACT

Impact of pretreatment hydronephrosis on the success rate of shock wave lithotripsy in patients with ureteral calculi

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A retrospective study design was used to evaluate the predictors of the one-session success rate of shock wave lithotripsy (SWL). We also examined the relationships between pretreatment hydronephrosis grade and one-session SWL success rates. The medical records of 1,824 consecutive patients who underwent the first session of SWL for treatment of urinary stones between 2005 and 2013 were reviewed. After exclusion, 700 patients with single, 4–20 mm diameter radiopaque calculus were included in the study. The mean patient age was 52.55±13.88 years. The mean maximal stone length (MSL) and skin-to-stone distance (SSD) were 9.24±3.91 mm and 110.80±18.98 cm, respectively. The average values for mean stone density (MSD) and stone heterogeneity index (SHI) were 707.04±272.10 and 244.90±110.16, respectively. One-session success rate was 68.4%, 75.0%, 75.1%, 54.0%, and 10.5% in patient with hydronephrosis grade 0, 1, 2, 3, and 4, respectively. Patients were classified into success or failure groups based on SWL outcome. Multivariate logistic regression analyses revealed that MSL (odds ratio

(OR) 0.888, 95% confidence interval (CI): 0.841–0.934, P<0.001), MSD (OR 0.996, 95% CI: 0.995–0.997, P<0.001), SHI (OR 1.007, 95% CI: 1.005–1.010, P<0.001), and pretreatment hydronephrosis grade (OR 0.601, 95% CI: 0.368–0.988, P=0.043) were significantly associated with one-session success. Pretreatment grades 3 or 4 hydronephrosis were associated with failure of SWL in patients with single ureteral stone. In the presence of severe hydronephrosis, especially hydronephrosis grade 4, physicians should proceed cautiously in choosing and offering SWL as the primary treatment for ureteral stone.

Key words: shock wave lithotripsy, ureteral calculi, hydronephrosis

I. INTRODUCTION

Ureteral stone is one of the most common urologic diseases. Affected patients can experience extreme pain. There are many options for ureteral stone treatment (e.g., shock wave lithotripsy (SWL), and ureteroscopic, laparoscopic, or open surgery). Since the 1980s, SWL has been recommended as a non-invasive, effective, first-line treatment for small-sized radio-opaque stones (≤2 cm diameter).[1] The overall stone-free rate after treatment using SWL is 80–90%.[2,3] Patient's age, sex, and stone characteristics (stone site, size, and density) are factors associated with stone-free rates. The number of stones, a history of urolithiasis, presence of renal colic, degree of hydronephrosis, and presence of a double J stent are additional factors associated with stone-free rates after treatment using SWL.[4-6]

Ureteral stone is the most common cause of ipsilateral hydronephrosis. The presences of one or more ureteral stones warrant urgent intervention to resolve the patient's symptoms and prevent damaging of renal function. The relationship between the degree of preoperative hydronephrosis and stone free rate after SWL has been studied. However, unanswered questions remain and a complete understanding would aid clinical decision-making during treatment selection.[5-8] We aimed to investigate the predictors of one-session success rate after treatment using SWL; we specifically focused on the significance of pretreatment hydronephrosis in patients with a ureteral stone.

II. MATERIALS AND METHODS

1. Patient cohort

Medical records were obtained from a database of patients (N=1,824) who underwent an initial session of SWL between 1st November 2005 and 31st December 2014 at Severance Hospital, Seoul, Korea. The study inclusion criteria were: single, 4–20 mm, radiopaque calculus located within the ureter on plain-film X-rays, presentation within 1 month prior to SWL treatment, and no evidence of stone migration. Patients with bilateral ureteral stones, urinary tract congenital anomalies, or single kidney, and those who received prophylactic medical expulsion therapy, were excluded from the analysis. Data from a total of 700 patients were eligible for inclusion in the analysis.

2. Good clinical practice protocols

The study was performed in accordance with all applicable laws and regulations, good clinical practices, and the ethical principles described in the Declaration of Helsinki. The Institutional Review Board of Severance Hospital approved the study protocol (4-2016-0791). The study was exempt from the written informed consent requirement because it used a retrospective design and because the patients' records and information were anonymized and de-identified before analysis.

3. Shock wave lithotripsy

SWL was performed using an electro-conductive lithotripter (EDAP Sonolith Praktis, Technomed, and Lyon, France) until 31st December 2011. On 1st January 2012, this lithotripter was replaced by an electromagnetic generative lithotripter (Dornier Compact Delta II lithotripter, Dornier Medtech, Wessling, Germany). All SWL procedures were performed using fluoroscopic guidance. The total numbers of shocks ranged from 2500 to 4000 in each session, at a rate of 60–90 shock waves per minute, and a launch intensity ranging from 16 to 55 MPa.

4. Demographic data and non-contrast computed tomography stone characteristics

A detailed medical history that included the number of past stone events was obtained for each patient. Stone characteristics such as location, maximal stone length (MSL), stone heterogeneity index (SHI), skin-to-stone distance (SSD), and mean stone density (MSD) were evaluated. SSD was measured in the axial plane, 45° from the vertical axis.[9] MSL was the longest stone length measured in three dimensions on non-contrast computed tomography (NCCT) images. We used the GE Centricity system (GE Healthcare Bio-Sciences Corp., Piscataway, NJ) for the measuring procedures. MSD was measured using bone windows on the magnified, axial NCCT image of the stone in the maximal diameter; the elliptical region of interest incorporated the largest cross-sectional area of the stone without including adjacent soft tissue.[10] The SHI was defined as the standard deviation of the Hounsfield units (HU) in the same way used by Lee et al.[11] Successful SWL treatment of the ureteral calculus was defined as the patient being rendered stone-free and asymptomatic, with clinically insignificant residual fragments ≤3 mm maximal diameter (measured by using a radiograph) within 2 weeks after single SWL treatment and not requiring additional treatment within a 3-month follow-up period.[12]

5. Hydronephrosis grading system

The hydronephrosis grading system was defined according to the degrees of change in the upper collecting system and used the Society of Fetal Ultrasound Grade system.[13] Grade 0 hydronephrosis was defined as no dilatation of the renal pelvis, with calyceal walls opposed to each other. Grade 1 was defined as dilatation of the renal pelvis without dilatation of the calyces (could also be present in the extra renal pelvis), and no parenchymal atrophy. Grade 2 hydronephrosis was defined as dilatation of the renal pelvis (mild) and calyces (the pelvicalyceal pattern was retained), and no parenchymal atrophy. Grade 3 was defined as moderate dilatation of the renal pelvis and calyces, blunting of the fornicies and flattening of the papillae, and possible mild cortical thinning. Grade 4 hydronephrosis was defined as gross dilatation of the renal pelvis and calyces with a ballooned appearance, loss of the borders between the renal pelvis, calyces, and renal atrophy indicated by the presence of cortical thinning.

6. Statistical analyses

The statistical comparisons of the continuous variables from the patients' demographic information were performed using the Student's or Welch's two-sample t-tests or the Wilcoxon rank sum test. One-way analysis of variance (ANOVA) was used subgroup analysis. After ANOVA, Tukey–Kramer's post hoc tests were used for between-group comparisons. Categorical variables were compared using Pearson's chi-square tests. Univariate and binomial multivariate logistic regression analyses were performed to define the factors that predicted post-SWL outcomes. The statistical analyses were performed using R software (version 3.0.3, R Foundation for Statistical Computing, Vienna, Austria; http://www.r-project.org).

III. RESULTS

Table 1 presents the results for the baseline characteristics of the 700 patients who underwent a first SWL treatment for single ureteral calculus. The mean patient age for the cohort was 52.55±13.88 years. The mean MSL and SSD values were 9.24±3.91 mm and 110.80±18.98 cm, respectively. The mean MSD and SHI values were 707.04±272.10 and 244.90±110.16 HU, respectively. The results for pretreatment hydronephrosis grade in patients with ureteral calculi were 76 (10.9%) cases of grade 0, 383 (46.9%) cases of grade 1, 177 (25.3%) cases of grade 2, 100 (14.3%) cases of grade 3, and 19 (2.7%) cases of grade 4, hydronephrosis. There were 573 (81.9%) cases of upper ureteral stone, 48 (6.9%) cases of mid-ureteral stone, and 79 (11.3%) cases of lower ureteral stone. The overall one-session success rate was 69.6%. The data from the study population were divided into two groups (treatment success or failure). The results indicated that there were statistical differences between the two groups in age (51.85±13.88 years in success group versus 54.16±13.80 years in failure group; P=0.042), MSL (8.38±3.23 versus 11.23±4.57, respectively; P<0.001), MSD (642.63±243.89 versus 854.30±276.48, respectively; P<0.001), SHI (252.06±114.08 versus 228.51±98.93, respectively; P=0.006), and grade of hydronephrosis (P<0.001). The one-session success rates were 68.4%, 75.0%, 75.1%, 54.0%, and 10.5% for patients with hydronephrosis grades 0, 1, 2, 3, and 4, respectively (Table 2). The results indicated that there was a statistically significant association between hydronephrosis grade and the values for MSL and MSD (P<0.001; Table 2 and Figures 1 and 2). The associations between hydronephrosis grade and one-session success rate and stone location were also significantly different (P<0.001).

Table 1. Comparison of clinical charicteristics between success and failure group after shock wave lithotripsy for ureteral stone

	Total cohort	Success group	Failure group	P-value
Patients, n	700	487	213	
Mean age ± SD (yr)	52.55±13.88	51.85±13.88	54.16±13.80	0.042[a]
Sex (%)				0.206[b]
Male	454 (64.9)	308 (63.2)	146 (68.5)	
Female	246 (35.1)	179 (36.8)	67 (31.5)	
Mean MSL ± SD (mm)	9.24±3.91	8.38±3.23	11.23±4.57	<0.001[a]
Mean SSD ± SD (cm)	110.80±18.98	110.66±18.90	11.15±19.21	0.751[a]
Mean MSD ± SD (HU)	707.04±272.10	642.63±243.89	854.30±276.48	<0.001[a]
Mean SHI ± SD (HU)	244.90±110.16	252.06±114.08	228.51±98.93	0.006[a]
Hydronephrosis grade				<0.001
Grade 0	76 (10.9)	52 (10.7)	24 (11.3)	
Grade 1	328 (46.9)	246 (50.5)	82 (38.5)	
Grade 2	177 (25.3)	133 (27.3)	44 (20.7)	
Grade 3	100 (14.3)	54 (11.1)	46 (21.6)	
Grade 4	19 (2.7)	2 (0.4)	17 (8.0)	
Stone location, n (%)				0.510[b]
Upper	573 (81.9)	403 (82.7)	170 (79.8)	
Middle	48 (6.9)	30 (6.2)	18 (8.5)	
Lower	79 (11.3)	54 (11.1)	25 (11.7)	
One-session success (%)	487 (69.6)	487 (69.6)	0 (0)	

[a]Based on student's or Welch's two-sample t-tests [b]Based on Pearson's chi-squared tests with Yates' continuity correction FSF, first-time stone formers; HU, Hounsfield units; MSD, mean stone density: MSL, maximal stone length; n, number; RSF, recurrent stone formers; SD, standard deviation; SHI, stone heterogeneity index; SSD, skin-to-stone distance

Table 2. Comparison of clinical charicteristics among groups according to the grade of hydronephrosis

	Grade 0	Grade 1	Grade 2	Grade 3	Grade 4	P-value
Patients, n	76	383	177	100	19	
Mean age ± SD, (yr)	51.12±14.54	51.87±13.85	53.54±13.51	54.14±14.24	52.53±13.48	0.434
Sex (%)						0.029[b]
Male	55 (72.4)	223 (68.0)	112 (63.3)	52 (52.0)	12 (63.2)	
Female	21 (27.6)	105 (32.0)	65 (36.7)	48 (48.0)	7 (36.8)	
Mean MSL ± SD (mm)	7.99 ± 2.80	8.49 ± 3.55	9.29 ± 3.52	11.74 ± 4.82	13.65 ± 3.32	<0.001[a]
Mean SSD ± SD (cm)	106.85±19.76	110.89±18.57	111.55±18.28	111.08±20.64	116.84±19.38	0.239[a]
Mean MSD ± SD (HU)	694.04±235.47	687.70±283.20	656.23±216.51	809.59±287.51	1026.54±273.84	<0.001[a]
Mean SHI ± SD (HU)	237.16±80.43	238.57±112.69	250.35±108.18	253.72±121.03	287.87±122.07	0.247[a]
Stone location, n (%)						
Upper	56 (73.7)	283 (86.3)	145 (81.9)	73 (73.0)	16 (84.2)	
Middle	5 (6.6)	9 (2.7)	16 (9.0)	15 (15.0)	3 (15.8)	
Lower	15 (19.7)	36 (11.0)	16 (9.0)	12 (12.0)	0 (0.0)	
One-session success (%)	52 (68.4)	246 (75.0)	133 (75.1)	54 (54.0)	2 (10.5)	<0.001

[a]Based on student's or Welch's two-sample t-tests [b]Based on Pearson's chi-squared tests with Yates' continuity correction FSF, first-time stone formers; HU, Hounsfield units; MSD, mean stone density: MSL, maximal stone length; n, number; RSF, recurrent stone formers; SD, standard deviation; SHI, stone heterogeneity index; SSD, skin-to-stone distance

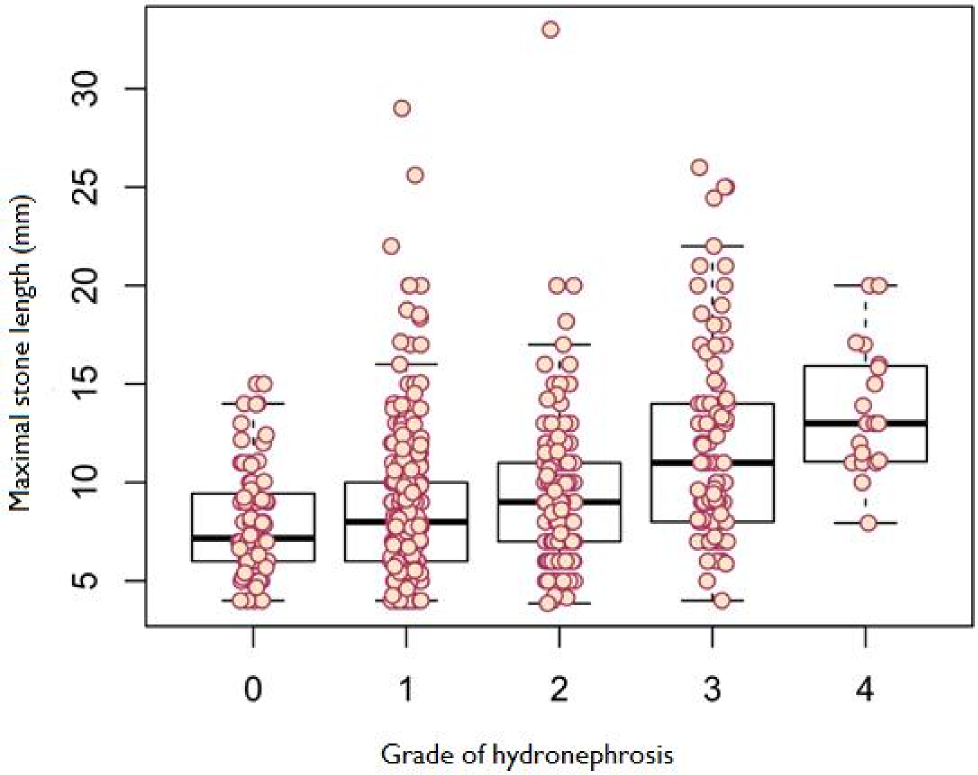

Figure 1. Comparison of maximal stone length according to grade of hydronephrosis. It shows a statistically significant association between hydronephrosis grade and the values for MSL (P < 0.001).

The results also indicated that there were statistically significant differences in sex (P=0.008), MSL (P<0.001), MSD (P<0.001), stone location (<0.001), and one-session success rate (P<0.001) between the two groups with hydronephrosis grade 0–2 versus grades 3 and 4. The univariate logistic regression models revealed that the following predictive factors were associated with SWL outcome

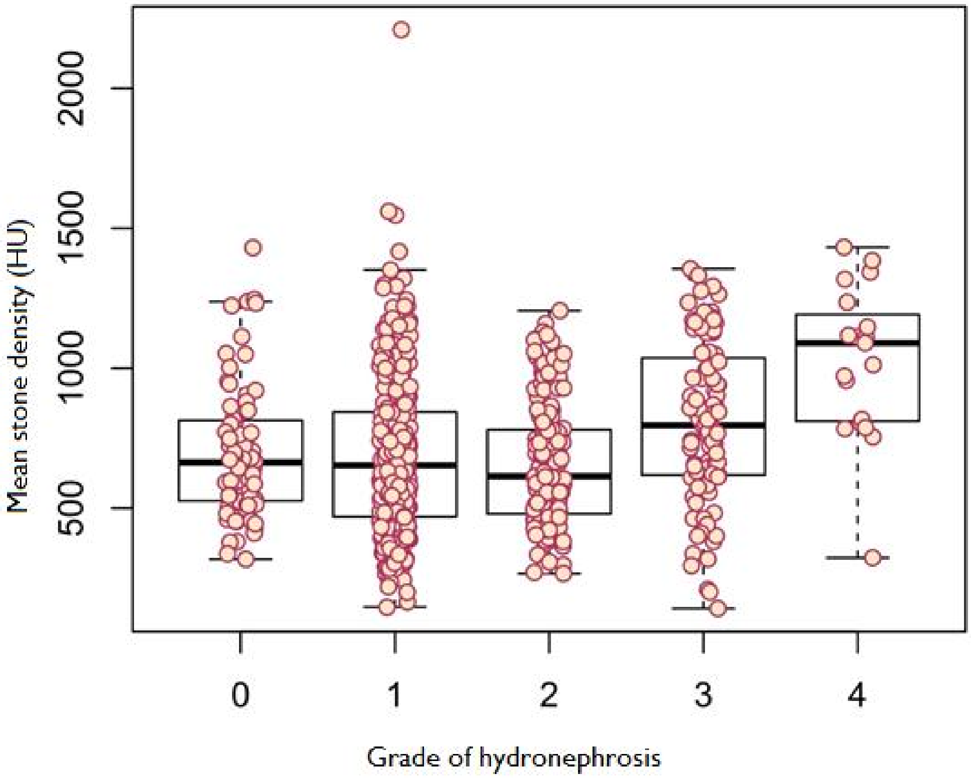

Figure 2. Comparison of mean stone density according to grade of hydronephrosis. It shows a statistically significant association between hydronephrosis grade and the values for MSD (P < 0.001).

after ureteral stone treatment: age (OR: 0.988, 95% CI: 0.976–0.999; P=0.043), MSL (OR: 0.822, 95% CI: 0.782–0.861; P<0.001), MSD (OR: 0.997, 95% CI: 0.996–0.998; P<0.001), higher SHI (OR: 1.002, 95% CI: 1.001–1.004; P=0.010), and hydronephrosis grade (OR: 0.309, 95% CI: 0.206–0.463; P<0.001). The multivariate analyses revealed that shorter MSL, lower MSD, and higher SHI were independent predictors and hydronephrosis grades 3 and 4 were negative predictors of one-session success after SWL treatment for ureteral calculi (Table 4).

Table 3. Comparison of clinical characteristics between groups with pretreatment hydronephrosis grade 0-2 and grade 3-4

	Total cohort	Grade 0-2	Grade 3-4	P-value
Patients, n	700	581	119	
Mean age ± SD (year)	52.55±13.88	52.28±13.84	53.88±14.07	0.251[a]
Sex (%)				0.008[b]
Male	454 (64.9)	390 (67.1%)	64 (53.8%)	
Female	246 (35.1)	191 (32.9%)	55 (46.2%)	
Mean MSL ± SD (mm)	9.24±3.91	8.67±3.47	12.05±4.66	<0.001[a]
Mean SSD ± SD (cm)	110.80±18.98	110.56±18.67	112.00±20.47	0.451[a]
Mean MSD ± SD (HU)	707.04±272.10	678.94±258.54	844.23±295.23	<0.001[a]
Mean SHI ± SD (HU)	244.90±110.16	241.97±107.60	259.17±121.33	0.121[a]
Stone location, n (%)				<0.001[b]
Upper	573 (81.9)	484 (83.3%)	89 (74.8%)	
Middle	48 (6.9)	30 (5.2%)	18 (15.1%)	
Lower	79 (11.3)	67 (11.5%)	12 (10.1%)	
One-session success (%)	487	431 (74.2%)	56 (47.1%)	<0.001[b]

[a]Based on student's or Welch's two-sample t-tests
[b]Based on Pearson's chi-squared tests with Yates' continuity correction
HU, Hounsfield units; MSD, mean stone density: MSL, maximal stone length; n, number; RSF, recurrent stone formers; SD, standard deviation; SHI, stone heterogeneity index; SSD, skin-to-stone distance

Table 4. Univariate and multivariate logistic regression of various clinical parameters for the prediction of one-session success aftershock wave lithotripsy

Parameter	OR	95% CI	P-value
Univariate			
Age	0.988	0.976–0.999	0.043
Sex (male)	0.789	0.558–1.110	0.177
MSL	0.822	0.782–0.861	<0.001
MSD	0.997	0.996–0.998	<0.001
SSD	0.999	0.990–1.007	0.750
SHI	1.002	1.001–1.004	0.010
Stone location			
Upper	Reference		
Middle	0.703	0.385–1.317	0.259
Lower	0.911	0.5b 54–1.533	0.719
Hydronephrosis Grade 3 & 4	0.309	0.206–0.463	<0.001
Multivariate			
Age	0.992	0.979–1.006	0.267
MSL	0.888	0.841–0.934	<0.001
MSD	0.996	0.995–0.997	<0.001
SHI	1.007	1.005–1.010	<0.001
Hydronephrosis Grade 3 & 4	0.601	0.368–0.988	0.043

HU, Hounsfield units; MSD, mean stone density: MSL, maximal stone length; n, number; RSF, recurrent stone formers; SD, standard deviation; SHI, stone heterogeneity index; SSD, skin-to-stone distance

IV. DISCUSSION

During the past decades, there have been significant changes in the management of urinary stone disease. Before the 1980s, open surgery treatment modality was used for most cases. This approach has been replaced by the use of minimally invasive surgical procedures such as ureterolithotomy, percutaneous nephrolithotomy, and SWL. Of these various options, SWL has been established as the preferred treatment for urinary stones due to its noninvasive character, few absolute contraindications, and resulting favorable clinical outcomes.[14,15] However, if a satisfactory outcome for SWL is not expected for a specific clinical situation, then the other benefits (e.g., non-invasiveness) are no longer available to the patient. Therefore, it is essential to accurately predict individual treatment outcome in terms of proper treatment selection for patients who are candidates for SWL.

Previous studies of SWL success rates have revealed that age, sex, and stone characteristics (stone site, size, and density) are factors associated with post-treatment stone-free rates.[5,8] Number of stones, a history of urolithiasis, the presence of renal colic, the degree of hydronephrosis, and use of a ureteral stent are other factors that affect success rate.[6] MSL is a potentially useful independent predictor of SWL outcome.[5,6] Patients with larger stones are more likely to experience failure of treatment and require further intervention.[16] MSD is also an independent factor associated with SWL outcome.[17] MSD is the mean value of the HU of each pixel in a specific stone area and can be easily determined from the NCCT image using a picture archiving and communication system.[18] This factor is also an independent predictor of SWL outcome.[11] SSD has been extensively investigated as a predictor of SWL success, but its use remains controversial for patients with ureter stones; SSD was a significant factor in one-half of all published studies.[9] Recently, SHI was introduced as a novel independent predictor of SWL success in patients with ureteral stone and a useful clinical parameter for stone fragility.[11] Other studies of stone site found that treatment of proximal and distal ureteral stones results in better outcomes compared with treatment of mid-ureteral stones. However, the results of recent studies suggest that there is no differences between-group in stone site and treatment results.[6,19] A history of urolithiasis has been reported as a negative factor affecting SWL success.[20,21] Ureteral stenting is a significant factor affecting stone-free rates.[19] Our study revealed that MSL, MSD, SHI, and severe hydronephrosis were significant predictors of one-session success rate after SWL treatment of single ureteral stone.

Several studies have evaluated the effects of preoperative hydronephrosis on the success rate of SWL; their findings have been inconsistent.[5-8] El-Assmy et al. divided a total of 215 patients with single distal ureteral stone into two groups according to the absence or presence of hydronephrosis. There were no significant differences between the degree of stone-induced hydronephrosis and SWL outcome (83.2% in the non-hydronephrotic group versus 74.2% in hydronephrotic group, p=0.27).[7] They performed a similar study of 284 patients with proximal ureteral stone and found that the stone-free rate was 80.3% in the hydronephrotic group, compared with 89.1% in the patients without hydronephrosis (p=0.12).[7] The results of Wang et al.'s multivariate analysis also suggested that hydronephrosis was not a significant factor for SWL treatment success rate (OR: 1.272, 95% CI: 0.471–3.433; p=0.635).[6] In contrast, Kageyama et al. found that mid to lower ureteral calculi and moderate-to-severe hydronephrosis were negative predictive factors of SWL treatment success rate.[8] Delakas et al. also found that the likelihood of SWL treatment failure increases with as the severity of the obstruction increases; hydronephrosis was associated with poorer results after SWL treatment (borderline significance; OR: 1.93, 95%CI: 0.99–3.77; p=0.053).[5] The results of our multivariate analyses indicated that severe hydronephrosis (grades 3 & 4) was independent predictor of a poorer outcome after SWL treatment for ureteral calculi (Table 4). Generally, ureteral stones cause sudden ureteral obstruction that results in the development of hydronephrosis; continuous obstruction results in deterioration of renal function. Hydronephrosis has adverse effects on renal function and decreases ureteral peristalsis and hydraulic pressure. These changes may adversely affect the expulsion of ureteral stones. This relationship may help explain our results. Severe hydronephrosis can also be linked to ureteral stone impaction into the ureteral mucosa. Impacted stones are frequently associated with ureteral polyps or strictures. A chronically impacted stone may cause inflammation and edema of the ureteral wall; these changes may also involve the surrounding tissues. The impacted stone can thus cause a more complete ureteral obstruction that result in a severe hydronephrosis. Impacted ureteral calculi are more difficult to fragment using SWL because of the lack of a natural expansion space for the targeted stones. There are currently two clinical definitions used for impacted stones.[22] The first commonly used definition of impaction is the inability to pass a wire or catheter beyond the stone at the initial attempt.[23] The second definition of impaction is that the stone has remained at the same location in the ureter for more than 2 months.[24]

Most urologists know that impacted stones are much more resistant to treatment using SWL. However, if currently available definitions for stone impaction are used, it is almost impossible to determine whether a specific ureteral stone is impacted at initial diagnosis. For these reasons, severe hydronephrosis can be used as ancillary clinical evidence of ureteral stone impaction in patients with ureteral stone when SWL is being considered as a primary treatment. European Association of Urology (EAU) guidelines recommend laparoscopic ureterolithotomy for treatment of large impacted stones when endoscopic lithotripsy or SWL has failed.[25] However, our study revealed that the one-session success rates were 54.0% and 10.5% in patient with hydronephrosis grades 3 and 4, respectively (Table 2). Therefore, even though SWL is less invasive compared with surgical lithotripsy; we are not sure whether physicians should offer SWL as a first-line therapy for ureteral stone patients with concomitant grade 4 hydronephrosis. Physicians and patients should discuss this low SWL performance rate before selection of SWL as a treatment for ureteral stones with accompanying grade 4 hydronephrosis.

This study had some inherent limitations because the use of a retrospective study design may have introduced sampling bias. However, we used a relatively large cohort of patients who underwent SWL for treatment of single ureteral stone. The presence of renal stones and anatomical considerations including the location of calyx and renal pelvic stones or stones in the infundibulopelvic angle were additional possible sources of bias. To overcome this type of limitation and more clearly elucidate the effects of various stone-related factors on SWL outcomes, we limited the study population to patients who only had ureteral stones. Unlike previous studies, we also classified hydronephrosis grade into five groups using a current grading system. This approach resulted in a better characterization of the contribution of hydronephrosis to treatment outcome. Prospective studies that use large sample sizes are needed to confirm our results regarding the relationships between pretreatment hydronephrosis and stone clearance.

V. CONCLUSION

The presence of grades 3 or 4 hydronephrosis before SWL was a negative predictive factor for one-session success in patients treated for a single ureteral stone. Severe hydronephrosis can be used as an indicator of possible ureteral stone impaction. In the presence of severe hydronephrosis, especially grade 4 hydronephrosis, physicians should be cautious when choosing and offering SWL as the primary treatment for ureteral stone.

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요관 결석 환자에서 치료 전 수신증이 충격파쇄석술 성공율에 미치는 영향

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장기돈

지난 30년 동안 충격파쇄석술(shock wave lithotripsy; SWL)은 2cm 이하의 방사선비투과성 요관결석의 1차 치료로 권장되어 왔다. 본 연구는 요관 결석 환자에서 충격파 쇄석술의 성공율에 영향을 미치는 요인을 분석하고, 특히 치료 전 환측 수신증과 충격파쇄석술의 성공율간의 관계를 알아보고자 한다. 2005년부터 2013년까지 초회 충격파쇄석술을 시행 받은 환자 1,824명을 의무기록을 후향적으로 조사하였고, 최종적으로 4-20mm 크기의 방사선 비 투과성 단일 요관결석을 가진 700명의 환자 데이터를 분석하였다. 환자의 평균 나이는 52.5세였고 평균 maximum stone length (MSL)값과 skin-to-stone distance (SSD)값은 각각 9.24±3.91 mm, 110.80±13.88 cm였다. Mean stone density (MSD)와 stone heterogeneity (SHI)의 평균값은 각각 707.04±272.10 Hounsfield unit 및 244.90±110.16였다. 수신증은 총 5등급으로 나누었으며 0등급이 76명 (10.9%), 1등급이 383명 (46.9%), 2등급이 177명 (25.3%), 3등급이 100명 (14.3%)이엇고, 4등급은 19명 (2.7%)으로 나타났다. 전체 대상군을 충격파쇄석술 성공군과 실패군으로 나누어서 비교 분석하였다. 두 군의 나이 (P=0.042), MSL (P<0.001), MSD (P<0.001), SHI (P=0.006), 그리고 수신증 등급 (P<0.001)은 통계학적으로 차이를 보였다. 수신증 등급을 0-2등급 군과 3-4등급 군으로 나누어 비교하였을 때, MSL, MSD 및 결석의 위치는 유의한 차이를 보였고 (P<0.001), 충격파쇄석술 성공율에서도 의미있는 차이가 관찰되었다 (P<0.001). 다양한 임상인자들이 충격파쇄석술의 성공율에 미치는 영향을 알아보기 위한 다 변량 분석에서는 MSL (odds ratio (OR) 0.822, P<0.001), MSD (OR 0.996,

P<0.001), SHI (OR 1.007, P<0.001), 그리고 수신증 등급(OR 0.601, P=0.043)이 독립적인 예측인자임을 확인할 수 있었다. 결론적으로 3-4등급의 수신증을 동반한 요관결석에서는 충격파쇄석술 성공율이 감소함을 알 수 있었다. 따라서 심한 수신증을 동반한 요관결석 환자에서 충격파쇄석술을 선택함에 있어 신중할 기해야 한다.

핵심되는 말: 충격파쇄석술, 요관 결석, 수신증